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Exploring metacognitive strategy use during note-taking for students with learning disabilities

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This mixed-methods study analysed over 200 interviews from 20 seventh-grade students with learning disabilities (LD). Students were instructed how to use a note-taking intervention during science lectures. The interview analyses were supported by pre- and post-intervention quantitative data. Data suggest that the intervention helped students identify important information; systematised the process of listening to, interpreting and using that information; and offered students a means by which to organise the information they were hearing. A discussion about metacognition and attention explores how these processes altered students' awareness of their own learning, as well as how they equipped students with a new strategy for holding onto and translating information from their science lectures into a useful set of notes. These findings have implications for how theorists conceptualise the relationship between metacognition and attention and how teachers use scaffolding to support the learning of students with LD.

Keywords: learning disabilities; middle school; note-taking; metacognition; strategy

Introduction

Middle-school students (grades 6–8) record notes during lectures and class discussions in an attempt to capture information and, in the process, learn more about the topic. Students also record notes to create a permanent record from which they can later study and prepare for tests. Recording notes allow students two opportunities to learn information: initially, when it is first taught and again, when they study the information. Middle-school teachers use lectures with note-taking about one-third to one-half of the time in their content-area classes (e.g. science and social studies) (Johnson 2008; Putnam, Deshler, and Schumaker 1993). In the USA, while inquiry and hands-on activities (e.g. labs and activities) are used in inclusive or co-taught science classes, Moin, Magiera, and Zigmond (2009) reported in their study that approximately 38% of class time was spent in lectures where students with disabilities recorded notes. When middle-school students record notes, teachers expect them to be able to discern important from unimportant information, record

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notes in sync with the lecture and use notes as a method of learning content (Badger et al. 2001; Bakunas and Holley 2001).

Students with learning disabilities (LD) often comprise the largest group of students who participate in content-area classes. Typically, these students have processing difficulties that interfere in efficient learning. In the classroom, note-taking is a particularly difficult task, as students must coordinate strategies and metacognitive skills that will help them transfer verbal information into written form. In fact, past research has shown that, compared to peers without disabilities, students with LD typically record less than half of the important lecture points, record fewer vocabulary words, and record less than half of the total lecture points (TLP) (Boyle 2010). While this research shows the extent of the problem for middle students with LD, less information is known about the role of metacognitive skills during the note-taking process.

To assist students with LD at learning content during teacher-led activities, such as lectures, teachers often provide students with guided notes. While guided notes have been shown to be useful for learning science content for students with disabilities (Boyle and Rivera 2012), there are two convincing reasons why teaching students note-taking skills, rather than using guided notes, might be more appropriate. First, many forms of guided notes (i.e. fill in the blank) do not actually teach effective note-taking skills (e.g. recording main ideas and vocabulary, using abbreviations, clustering like ideas together) (Lazarus 1991). Second, guided notes are very time-consuming for teachers to create (e.g. Lazarus 1993, reported that 18–25 pages of guided notes were developed for just one chapter) and students must rely upon the teacher to provide these. In other words, teaching students note-taking skills allows them to become independent and autonomous learners.

In this mixed-methods study, we examine how seventh-grade students with LD used a strategic note-taking (SN) intervention to interact with the information in their Science lectures. We ask how did students draw on the SN intervention to expand their capacity for metacognition and better use executive functions? Our analysis builds on existing work in the areas of metacognition and working memory (WM), ultimately, establishing linkages between these two fields.

Metacognition and classroom learning

Metacognitive skills play a critical role in many problem-solving activities that students encounter in the classroom everyday. In fact, Akyol, Sungur, and Tekkaya (2010) found among seventh-grade students that their cognitive and metacognitive strategy use was related to their science achievement. Oral communication, verbal reasoning and comprehension, written communication and language acquisition are some of the areas that require the use of metacognitive skills (Conner 2007; Nuthall 2000). Of course, lecture learning and note-taking encompass many of these areas and often place heavy demands on metacognition while learning science content (Evers and Spencer 2011). Because of the multitask nature of note-taking during lectures, where students must listen to incoming verbal information while concurrently recording what was just stated by the teacher, the act of recording notes during lectures represents an ideal academic task with which to explore how students with LD use metacognitive skills.

Attention and metacognition

In a broad sense, metacognition is often referred to as a person's ability to think about how one thinks and learns. According to Flavell, Miller, and Miller (2002), metacognition

includes 'both what you know about cognition and how you manage your own cognition' (p. 164). These components are sometimes referred to as metacognitive knowledge and metacognitive monitoring and regulation. More specifically, metacognitive knowledge pertains to a person's knowledge about their own cognitive processes (e.g. I can remember information better that is written down), tasks (e.g. I can remember organised information better than unorganised) and strategies (e.g. if I cannot write down everything during a lecture, I will just write the vocabulary word and come back later to write out its definition) (Flavell 1979). Metacognitive monitoring and regulation refer to the management of cognitive activities during problem-solving (Flavell, Miller, and Miller 2002). Regulation often includes planning, monitoring and evaluating progress on learning and problem-solving tasks (Brown 1987; Ku and Ho 2010). Planning involves identification and selection of appropriate strategies and allocation of resources, such as attention, and involves goal setting, activating background knowledge and awareness of time. According to Schraw, Crippen, and Hartley (2006), regulation involves knowledge about strategies and procedures and knowing when (and why) to use a particular strategy given the demands of the task.

Accordingly, metacognitive monitoring and regulation play a major role in selecting, monitoring and evaluating strategy use during learning tasks such as note-taking. Students with good metacognitive self-regulatory skills tend to change their strategies based upon their success or failure on the task (MacLeod, Butler, and Syer 1996). When a strategy is successful, they have a tendency to include it in their repertoire of tools for problem-solving. Cognitive psychologists believe students have a 'cognitive toolbox' of general problem-solving tools, making do with what they have to solve a variety of learning tasks and modifying and refining these tools over time as they become more proficient at solving different kinds of learning tasks (Flavell, Miller, and Miller 2002). Hence, teaching students the metacognitive skills needed for note-taking should lead to improved note-taking skills and, in the process, improved learning of lecture content.

As students learn how to solve new tasks, the role of attention takes on a heightened relevance. At an early age, students begin to understand that attending selectively to one task reduces or diminishes their recall for secondary or incidental tasks (Flavell, Green, and Flavell 1995). Attention during lectures with note-taking plays a pivotal role, as students learn that not only is 'attention' a limited resource that must be used judiciously, but, once the lecture begins, they must adjust their level of attention in order to focus and capture important lecture information (e.g. being fatigued and only half listening to a lecture would result in different learning outcomes than if the student were fully awake and focused) and they must use selective attention to decide which lecture information to keep (and write down) and which aspects of the lecture to ignore (Flavell, Miller, and Miller 2002). Further, even though two students are focusing attention and listening to the same aspect of the lecture, their notes may reflect different representations of the same lecture concept.

Attention and WM

Likewise, from a WM perspective, attention and regulation of attention is a function of the central executive. Executive functions often include, but are not limited to: metacognitive and strategy use, regulation of attention and memory mechanisms, such as WM (Anderson 2002; Eslinger 1996). From this perspective, executive processes are primarily responsible for directing and regulating attention during learning tasks. In fact, Kane et al. (2007) refer to the role of 'executive attention' as one that: (a) helps keep active long-term memory

traces in WM, via rehearsal or coding processes (e.g. chunking, imagery); (b) sustains activation of information over a long term; (c) allows for the retrieval of no-longer-active information; and (d) inhibits irrelevant information during learning tasks. Likewise, others (Miyake and Friedman 2012; Miyake et al. 2000) have referred to these executive functions of attention as updating (e.g. monitoring and renewing new information in WM), shifting (e.g. moving between tasks or mental sets) and inhibition (e.g. overriding prepotent responses), which all play a significant role during note-taking from lectures.

Cognitive strategies and metacognitive skills of students with disabilities

Among students with disabilities, Cutting and Denckla (2003) found that there was not a deficit in 'attention' per se, but rather in the deployment and allocation of attentional resources during learning tasks that accounted for their learning deficits. Likewise, problems with 'attention' have also been observed among students with LD. Swanson and Saez (2003) have hypothesised that the crucial component of the central executive in students with LD involves controlling attention. To support their claim, they found that students with LD had particular difficulty on tasks that involved divided attention (e.g. remembering digit strings while performing a sorting task that used categories), suppressing irrelevant information (e.g. inhibition of irrelevant words on a word recall task) and simultaneous storing and processing of verbal and visual information, which place heavy demands on attention.

Of the different learning tasks that students encounter in their school day, note-taking during lectures is perhaps one of the most cognitively demanding tasks. Gathercole et al. (2008) feel that those tasks that required simultaneous processing and storing of information (e.g. detecting and recalling rhyming words in spoken poems or listening to a sentence and counting the number of words) tend to be the most difficult, particularly for students with WM deficits. According to these researchers, students' errors represented deficits that were indicative of failures of both WM and sustained focused attention.

According to Peverly (2006), during a lecture in which students record notes they must do three main tasks: hold/rehearse incoming verbal lecture information temporarily, quickly construct representations of the information (i.e. translate or paraphrase it as it relates to their own knowledge) and then transcribe the components onto paper before information in the verbal store is lost and before new incoming information is processed. In other words, students must keep an active representation of what they are hearing in WM in order to comprehend and transcribe it, as they are continuously updating incoming content as it is spoken (Piolat, Olive, and Kellogg 2005). During this process, the central executive (i.e. the attention system of the WM system in Baddeley 2000) appears to play a major role in switching attention back and forth from listening to the speaker to recording notes, inhibiting irrelevant lecture points (i.e. deciding which lecture points are relevant to record and which are irrelevant), and regulating ideas, moving them from long-term to WM as they relate to incoming lecture points (Altemeier et al. 2006).

Consider the actual task of listening to a teacher's lecture and recording that information as s/he lectures. If teachers present content at about an average rate of 110 words per minute (wpm) during lectures (Boyle 2010; Titsworth 2004) and students write at an estimated rate of 17 wpm (assuming four letters per word) on a writing sample in which there is no cognitive effort (e.g. wrote first name for three minutes at an average of 68 letters per minute, Boyle 2010), then the presentation rates may be six times faster than students can write. Once in learning situations where students must use metacognitive skills and executive

attention to direct learning, many of them will undoubtedly have difficulty processing the information fast enough to record notes accurately and completely.

Unfortunately, students with disabilities have difficulties naturally deploying and using strategies during learning tasks (Evers and Spencer 2007). For many students with LD, they either lack a strategy to effectively approach an academic task, use ineffective or inefficient strategies, use less sophisticated metacognitive skills which are necessary to recognise when and where (under what circumstances) to use a strategy and have difficulty activating and regulating strategic behaviour (Ellis and Lenz 1996; Gersten et al. 2001; Graham and Harris 2003; Pressley et al. 1989; Wong 1996). While many of these issues involve the effective use of metacognition to use the strategy, some issues involve using an effective strategy in academic situations.

According to Gunstone (1994), most students are metacognitive to an extent and that the degree of their adroitness of metacognition will influence the extent to which students deploy strategies. Students who are unaware of their own repertoire of strategies would not likely deploy them when faced with a learning task that required a specific strategy. It is only through an awareness of cognitive strategies and an extensive use of them that students will automatically deploy cognitive learning strategies (Wong 1996). It is students' strategic knowledge and metacognitive skills that differentiate good students from those at-risk for academic failure (Evers and Spencer 2007). This statement particularly holds true in special education, where strategy deployment has been an issue that researchers have been grappling with for many years. Hence, many of the strategies that have been developed for this population employ steps that serve to cue students to perform certain actions or use specific sub-strategies (e.g. self-questioning) (Ellis, Lenz, and Sabornie 1987). Once students have mastered the strategy with low cognitive load materials, teachers then must teach students how to generalise the strategy in other settings (e.g. general education classes) and with other materials (e.g. teachers' lectures). Much of this training involves teaching students metacognitive skills so that they recognise the task and task demands, can deploy the correct strategy and then use it with these new materials. Using this generalisation method can be difficult for students with disabilities, as teachers often have to prompt students to use the newly learned strategy and sometimes students deploy the strategy but struggle to use it with new materials. Another method of generalisation that is becoming increasingly popular, particularly in inclusive classrooms, involves teaching all students, including students with disabilities, to use the strategy in the general education setting with the materials that they will eventually be using (in this case, the teacher's lectures).

While there are a couple of studies that examined the role metacognition plays in note-taking among college students (Bonner and Holliday 2006; Castello and Monereo 2005), no studies have examined metacognitive skills among pre- and early adolescents who used note-taking, particularly among students with LD. Hence, this mixed-methods study sought to explore how students with disabilities used the SN intervention in inclusive seventh-grade science classes. This is the first study to examine how a note-taking intervention is used by students with disabilities, via post interviews, and specifically examine the role that attention plays in strategy deployment.

Methods

Participants

Students were recruited in two suburban middle schools in the Northeast region of the USA. First, seventh-grade science teachers were recruited for participation in the study.

Participating teachers received a monetary stipend for the development and implementation of lectures in the study. Consent forms were sent home to the parents of all seventh-grade students within the classrooms of those teachers, and an entry into a lottery to receive 1 of 24 twenty-dollar gift cards was advertised as an incentive.

A total of 36 participants consented to participate in the note-taking intervention. The majority of participants were European-American (61%) and male (55.6%); there were seven (19%) African-American students (three males, four females), three (8%) Hispanic-American students (two males, one female) and one Asian-American (2%) student (male). Twenty of the participants were previously diagnosed by their school division as having LD and 16 of students had no disabilities (e.g. average achieving peers). Since our selective sample involved examining the cognitive and metacognitive skills of students with LD, we selected only those students with LD and no other type of disability (e.g. autism, intellectual disabilities). Prior to the study, students categorised as LD were identified by their school district through testing that used severe discrepancy methodology (i.e. intelligence and academic achievement) and closely followed state and federal guidelines that are used in the US. Since we were interested in looking at changes in metacognitive skills of students with LD, only the transcripts of students with LD were analysed.

Materials and procedure

Pre-/post-intervention note-taking task

Students were administered a mock lecture to assess their pre- and post-treatment note-taking ability. In this measure, students were asked to listen to and record notes on a 15-minute video-based lecture entitled 'Electro-Plasma Rockets'. Once the lecture was over, students' notes were collected and they were provided another piece of blank paper to record as much information as they could recall from the lecture; this is a measure of immediate free recall of information learned. Next, students were given a 10-question multiple-choice quiz based on the content of the lecture, which was administered before the note-taking intervention was introduced and again at the conclusion of the study. Although the post-treatment lecture was the same as the pre-treatment, post-treatment did not occur until six months later, after all students were exposed to the treatment science modules.

Graduate-level students scored the notes based on three scores: Cued Lecture Points (CLP), TLP and Vocabulary. CLP represent the number of CLP verbalised during the lecture (e.g. 'This is important to remember,' 'There are three types of plasma engines') that the student recorded. TLP represent the raw overall lecture (both cued and non-cued) points that were recorded by the student. Vocabulary represents the raw number of instances the student wrote down one of the vocabulary words within the lecture.

SN intervention (CUES+ strategy and SN paper)

The SN intervention, adapted from Boyle (2010, 2013), Boyle and Weishaar (2001), and Lee et al. (2008) comprised two parts, the first word mnemonic CUES+ (i.e. 'C' – Cluster, 'U' – Use, 'E' – Enter, 'S' – Summarise, '+' – Plus) strategy and the SN paper:

- *CUES+ strategy*: In the CUES+ strategy, each step prompts the student to perform an action using lecture information and the SN paper. In the Cluster step, students are asked to cluster lecture information into manageable units of three to six related

ideas and record the chunked ideas on the SN paper. The Use step prompts students to pay attention and listen for teacher cues (i.e. number cues and importance cues) during the lecture and, when they hear these cues, record the lecture points that are associated with them. In the next step, Enter, students are asked to listen for vocabulary words and record any vocabulary words from the lecture in the appropriate area on the SN paper. In the Summarise step, students are asked to write a word or words that would categorise the three to six lecture points they have already listed (i.e. clustered together) on the SN paper. In the Plus (+) step, students should add or use abbreviations, pictures or symbols to personalise your notes.

- *SN paper*: The SN paper placed boxes with guidelines for types of information students should record. At the top of the paper, students recorded the topic and include any background knowledge they may have on the topic. Students, then, group together three to six main points from the lecture with details. At the end, students were prompted to summarise the lecture ideas. There was also a separate section for key or new vocabulary words to be listed and defined.

Modules

Participating teachers developed scripted lectures for each lesson, or module, presented to the students. This was done to ensure uniformity of content across classrooms (i.e. regardless of class/school, all students were exposed to the same science content). Each lecture included specific vocabulary words and a written script for teachers to read aloud during the lesson. These scripts included CLP and Non-CLP. There are two types of cues that teachers use to alert students to important information: emphasis cues and organisational cues. CLP that contain emphasis cues were those lecture points that had a verbal cue proceed it to emphasise its importance. (e.g. 'Please write this in your notes: A plasma engine uses only one-tenth of the fuel that a chemical rocket engine would use.') CLP that contained an organisational cue were used by teachers to help students organise chunks of related information. ('There are three kinds of plasma engine rockets: ion drive, Hall thruster and MPD thruster.') Non-CLP were pieces of information that did not have a prompt or cue before their presentation.

First, students were exposed to video lectures that were recorded by seventh-grade science teachers and then their own science teacher used the other half of the scripted modules in class. The purpose of the videotaped lectures was to control content and other extraneous variables (e.g. additional teacher prompting and feedback) while students used the SN intervention. In this way, regardless of which class/school, students would be exposed to the lecture in the same manner. Next, scripted lectures were used simulate a more authentic science lesson.

Pre-/post-module content tests

Similar to the quiz given during the Pre-/Post-Intervention Note-Taking Task, a 10-point multiple-choice quiz was presented before and after a module was presented to the students. This was used to gauge how much pre-existing content information students had surrounding a specific module topic and how much information was gained through listening to the lecture and recording notes. Students did not necessarily have time to study their notes after the lecture; therefore, the post-module tests were merely a measure of the effectiveness of taking, not using, their notes.

Post-module interviews

Post-module interviews were administered to students identified with a LD to assess their experience learning and utilising the SN strategy. Students were interviewed after each module that was taught by their teacher, resulting in each student being interviewed 10 or more times throughout the study. These interviews were administered by undergraduate and graduate student research assistants, all of whom were trained on how to interview students by a professional qualitative researcher. They were instructed in how to interview students, procedures for properly probing for information, how to transcribe interviews and what problems they might encounter during interviews. These interviewers relied on a semi-structured interview protocol that focused on the students' experiences using the note-taking strategy, as well as how they believed their note-taking was changing over time. Interviewers were given the freedom to make slight alterations to the protocol when necessary.

Data collection

Initially, participants' baseline note-taking ability was assessed using the Pre-Intervention Note-taking Ability Task. Students subsequently participated in two SN intervention training sessions. During the first 50-minute training session, the principal investigator followed a scripted lesson and trained students on how to use the CUES+ strategy with the SN paper. Throughout the training, the investigator provided a brief description of SN intervention, modelled the technique and guided students through practice portions of a videotaped lecture. During the second session, students used the same videotape, but with new SN paper. Unlike the first session in which the lecture was periodically paused for feedback, during the second session the videotaped lecture played in its entirety so they could acclimate to the pace of a typical lecture.

Upon completion of the training, teachers presented the pre-scripted modules during the students' seventh-grade science class. One or two modules were presented each week, for a total of 20 modules. In each session, students were provided with the pre-module test at the beginning of each class period, the scripted module and the post-module test at the conclusion of the lesson. These pre- and post-module tests were similar to the quiz given during the Pre-/Post-Intervention Note-Taking Task. They consisted of a 10-point multiple-choice quiz that was administered before and after a module with the goal of determining learning gains.

In addition, after each session trained research assistants conducted 5–10-minute interviews with all participants with LD. They used a semi-structured interview protocol that focused on the students' experiences using the SN intervention, as well as how they believed their note-taking was changing over time. The number of interviews each student completed over the course of the intervention varied depending on attendance and ranged from 10 to 17. After the last module was presented, the Post-Intervention Note-taking Ability Task was given to the students.

Data analysis

Students completed the note-taking task before and after the intervention implementation as a pre- and post-measure. Independent raters were trained by the principal investigator over a two-hour training session and scored all the notes using a key created by the principal investigator. The raters counted the number of CLP, TLP, and Vocabulary Instances (VI) for each

set of notes. Inter-rater reliability that was conducted with a sample of 20% of students' notes was found to be .94. It should be noted that these independent raters were not involved in any of the post-module interviews. We examined students' pre- and post-intervention scores in all of these areas, both looking at the students as a group and analysing their individual scores.

All interview transcripts were inputted into Atlas.ti. In a first cycle of coding, we used a process of open coding to analyse the transcripts in chronological order and identify both etic themes that reflected the aims of the intervention and our guiding conceptual frameworks and emic themes that emerged in participants' experiences with the CUES+ strategy (Hammersley and Atkinson 2007). In our second cycle of coding, we sought to identify several cases that would allow us to explore in more depth how students were using the SN intervention to develop their note-taking skills. To this end, we used the quantitative findings to isolate three cases which best exemplified the sample of 20 students with LD. These three students were selected because their scores from notes were similar to the post-intervention mean score for the entire group. By doing so, we were able to analyse in more depth by identifying evidence of change in participants' approaches to note-taking over time. This approach helped us triangulate our analysis. Juxtaposed with our quantitative data, we found that the interviews had tremendous explanatory power as we sought to understand how successful students used the SN intervention to become better note-takers.

Limitations

As a relatively short-term study, we were interested in examining students' engagement with our SN intervention solely during the intervention period. As such, we do not claim to understand the long-term impact of this scaffolding approach. Further, we focused specifically on note-taking in science classes, and our study does not offer us any insight into how students might have transferred these skills to better employ executive functions in other subjects or in other academic tasks. Therefore, our findings reflect our goal of understanding what kinds of cognitive shifts occurred for the students in our study as they used the SN intervention.

Findings

Quantitative findings

Table 1 presents the means and standard deviation of CLP, TLP and VI of participants before and after the implementation of SN intervention. The SN intervention was developed to signal students to perform specific actions while note-taking.

As presented in Table 2, participants demonstrated increase in all note-taking scores. They demonstrated the largest increase in their ability to record CLPs. Figure 1

Table 1. Means and standard deviations for note-taking task scores pre- and post-intervention.

Note-taking task score	Pre-intervention mean (standard deviation)	Post-intervention mean (standard deviation)
CLP	1.16 (1.98)	6.68 (4.04)
TLP	3.50 (3.01)	11.5 (6.71)
VI	3.70 (2.52)	15.26 (5.47)

Table 2. Percentage of total points note-taking task scores pre- and post-intervention.

Note-taking task score	Percentage of total points	Percentage of total points
CLP	7.73	44.53
TLP	4.50	14.74
VI	4.07	16.77

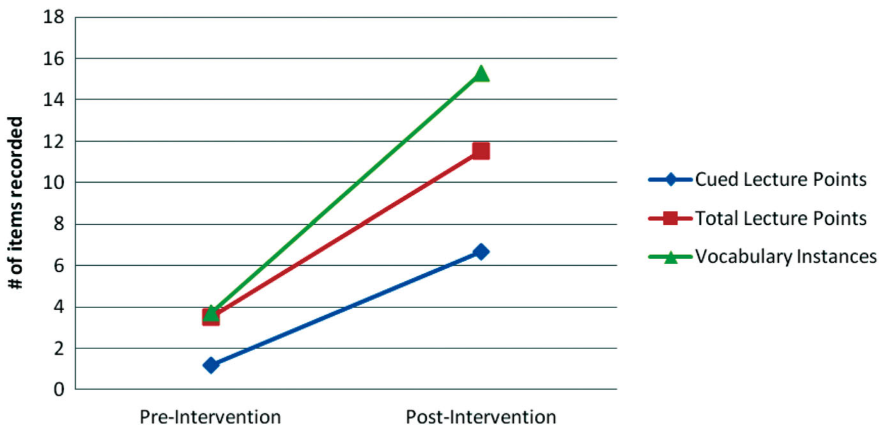

Figure 1. Pre- and post-intervention note-taking scores of participants.

demonstrates that there was an overall increase in students' recording of cued lecture notes, overall number of lecture points and number of vocabulary words recorded.

Qualitative findings

Almost all of our study participants used the SN intervention significantly to change how they went about taking science lecture notes and how they organised and processed information from science lectures. We found that the note-taking strategy served as a scaffold, directing the students' attention to important points, systematising the note-taking process and helping them to organise information.

Identifying important information

Taking notes with CUES+ served to direct students' attention to key points and approaches to interpreting and recording information from the science lectures. Students repeatedly reported picking up on points they would have missed without the CUES+ strategy. Our Year 1 interviews made it apparent that there were two primary mechanisms for drawing students' attention to key points and vocabulary: teacher cues and testing alignment.

These teacher cues, which are an integral component of the CUES+ strategy, served as explicit hints to students about what science content was important enough to include in their class notes. Teacher cues were both verbal (in the form of key phrases) and non-verbal (in the form of notes written on the blackboard), literally directing students to pay attention to particular points in the lecture and serving as an indication of what information was important enough to write down and retain for later use. Out of all of the note-taking

'rules' set out in the CUES+ strategy, these cues seemed to be the easiest one for students to decode and follow. Most students pointed to verbal cues as the primary means by which they made decisions about what points were important enough to include in their notes. For example, these study participants all expressed the usefulness of remaining attentive to the teacher's (or other speaker's, in the case of the video lectures) specific language, a skill that can be especially difficult for students with LD:

S22:	The thing that makes a point important is when the teacher tells you to write it down. And when you're actually watching the video, if it's important they're basically giving you hints like, it's going to be on the text. And it's something you should be really studying and should be able to know.
S24:	I don't really write everything down, I just write the things [the teacher] says is important.
S15:	The teacher cues … help you know … Like when the teacher tells you to 'write this down', you already know to write it, to be prepared … I used to not know that and I used to not write stuff down.

However, a number of students also told our interviewers that seeing points appear on the board was another central clue to them to begin writing, as was evident in this exchange:

Interviewer:	Of all the things, why did you decide to write this down?
S33:	Because that was the only thing on the board.
Interviewer:	Ok, so you wrote it down because it was on the board?
S33:	Yeah.

This act of merely copying off the board every point that is written there does not involve the same complex cognitive functioning as listening for the teacher's verbal cues and then interpreting and restating in note form the most important information that has been spoken aloud. It is important to acknowledge this fundamental difference between the types of teacher cues that served to direct students' attention, as well as how these cues were interpreted by the students. A number of students explained that they viewed teacher cues as code for what was going to appear on the post-test, which prompted them to value CLP more than other lecture points.

The pre-tests and post-tests used to gauge the effectiveness of the SN intervention also provided crucial scaffolding for student learning. Almost all of the participants discussed using the pre-test to gauge which points were important enough to include in their notes. That is, students would take a pre-test in which they did not know most (or all) of the answers and then, during the lecture, rely on their memory of the unfamiliar questions to decide what information they needed to learn in order to pass the post-test. Though they did not necessarily know how they had scored on the pre-test, as they listened to the lecture and processed what they were hearing, students recognised which questions they had answered incorrectly in the pre-test. As they identified gaps in their previous knowledge, they understood that these were the items to which they had to pay attention and include in their notes in order to pass the post-test. In this way, implicit messages around pre- and post-test alignment became a cognitive scaffold through which students sorted out extraneous information and made key decisions about what would be the most useful takeaways from a given lecture. This process was explained clearly in one interview as facilitating the shift from merely 'guessing' at test answers to actually 'remembering' content from the lecture:

S3: ‘Cause [answers on the pre-test are] a guess. And then when you hear it on the video [lecture], you know that that [answer] is wrong, because you still remember it [from the pre-test].

This connection between the tests and the lectures was evident in an interview with another participant, who used testing as a scaffolding mechanism to identify important vocabulary terms without the help of any teacher cues:

Interviewer: How do you know when the teacher is speaking to write it down? … Like, you have ‘cell membrane’ right here. Why did you write down ‘cell membrane?’

S28: It’s, the teacher didn’t even tell me to write down ‘cell membrane’, it was just the vocabulary [from] the pre-test.

Further, a number of students noted that merely taking down the notes using the CUES+ format was a way of studying for the tests. S3 pointed out,

> It’s like studying when you write a lot of notes down … [You] picture phrases in your head, so you remember everything that you know from the notes that you took, and you can put it right into the quiz.

Together, teacher cues and the scaffolding that emerged through the pre- and post-tests served to direct students’ attention to key information. For students with LD, even this simple task of identifying what is important enough to include in class notes can be a difficult one with real implications for what they are able to record and retain. Students with LD generally have difficulty processing information fast enough to record everything they hear, and it can be a struggle for them to effectively wade through extra information in ways that would make that information useful to them after a lecture. For our participants with LD, then, simply knowing how to identify important lecture points with some speed was a meaningful lesson.

Systemising the process and organising information

In addition to using explicit and implicit messages to draw students’ attention to important lecture points, the CUES+ strategy facilitated students’ engagement with the note-taking process and helped them understand note-taking as a way of organising and interpreting the course content. Our data show that note-taking with CUES+ became more systematic and less arbitrary for students, who used tools such as abbreviations, main points, summaries and definitions to break down a larger task into its component parts and thus demystify the process. The highly structured CUES+ format helped to direct students’ attention to key points and offered them a means by which to organise the information they encountered in the lectures. Further, for many this format made it possible to focus simultaneously on the twin tasks of listening and writing, tasks that are typically quite challenging for students with LD.

A number of students pointed to this organisation as having helped them think more clearly about the lecture topics, as is evidenced in the following statements from study participants:

S23: [The CUES+ notes are] more organized, and when it’s more organized, it’s easier to look at … Regular notes is a paragraph, and it’s just confusing to try to find something in a paragraph.

S17: With the CUES+ notes you can see that you wrote down the topic for that day, you wrote down three main important [points] and stuff like that. With your regular notes, sometimes you kind of skip over a few things and just [clump] it all together and not remember what it was on or when did you do it.

S26: When I write down stuff, I think about it when I'm writing it down, and then I remember it. If they ask me something that I wrote down, I'll know the answer.

S3: When you do this it's like studying in a way. So for the joules and stuff, gravity is made up of joules, I knew that one because we just learned that and I put that thing right here.

The 'studying' to which these students are referring is, in effect, a complex process of multi-tasking that involves organising, interpreting and using information.

For some students, this meant they wrote more as a result of using the CUES+ strategy. These participants explained that incorporating abbreviations, via the Plus (+) step, helped them write faster and include more of the lecture points because they were able to spend less time writing each point, which allowed them to cognitively move onto the next thing that was being said in the lecture. Students wrote more, both because the format motivated them to do so and because the strategy demanded it of them:

S3: It takes more time … I write more … [The CUES+ strategy] makes you want to fill out the paper.

S26: I can write more stuff in smaller spaces

Interviewer: Okay. So why was that so good?

S26: Because when you have to get a lot of notes down, it's easier to get them down, and you can do it faster.

Including enough information, these students claimed, gave them adequate notes to do better on the post-test. Even more importantly, the act of taking notes in a way that directed their attention to the right kind of content allowed them to better remember the content itself in preparation for the test:

S3: When you do the CUES+ on the strategic note-taking, It's a lot easier because you remember what you're doing while you're listening to the video, because I actually just understand that now. It's a lot easier because you study while doing your strategic note-taking. You remember everything on the paper, which is the basically the problems on the test. And if you learn in the [CUES+ lecture] video, you still remember stuff from there too.

S26: I think of the stuff as I'm writing it down, and I'll remember it if there's a test on that.

Interviewer: Can you give me an example of something you elaborated on and wrote more notes on?

S26: Before asked what fluid is. And I didn't know it was a liquid or a gas. I thought it was just a liquid.

Paradoxically, other students said that the CUES+ strategy was helpful precisely because it gave them the tools to write less – and, therefore, more topically focused – information. Those who benefitted from writing less told interviewers that the format and categories of CUES+ (e.g. summarising the three to six main points, separating the notes into sections

by topic, and being encouraged to write vocabulary words) helped them sift through the information in the lecture so that they could pull out only the points that would ultimately be relevant to the test, allowing them to study more effectively and ultimately remember more:

S11:	When you find a good fact and then you put it to the three main points and then you go over it, and when you keep reading [it] over and over, it just keeps, you keep feeling it and then it stays in your brain forever.
S13:	I'll put a picture or I'll put something like this [points to his notes in the 'Name 3–6 main points' section]. Like, a single cell … won't live, but if it has many cells it will live. All the cells will live.
Interviewer:	Do you think that those helped you?
S13:	Yeah.
Interviewer:	Why?
S13:	'Cause if I have a picture, I have a visual of what the thing looks like.

Summarising is an act that involves listening to what is being said, conceptualising the meaning of the statement, making a quick decision about what is most important about that statement, and then writing it down in a restated form. In the context of a fast-paced science lecture, all of these steps must happen in a matter of seconds. This was especially the case in the videotaped lectures, during which there was no opportunity for the speaker to slow down, pause or clarify a concept while the students summarised points in their SN notes. Several students pointed to this process as the means by which they gained a deeper, more lasting understanding of the content in their science class:

S23:	It's different [than regular notes] because it's coming from you and it's coming from your mind and it's in your own words … I think you actually learn more by writing it down, because you actually have to think before you write it down. So I think there's more thinking before you actually write it and more time for you to get to understand it and learn it before you actually put it down on paper.
S17:	I liked the part when we had to summarize at the end, summarize the final that you didn't know … Because it's challeng[ing] your brain, like let's see what I know about this before I learn about it. And then when they say something that you might've said, like oh see, I knew that.

The CUES+ format (i.e. the Plus+ step) also affords students the space and the permission to include explanatory drawings or helpful symbols, expanding the modalities that are available to them as they attempt to understand complex scientific concepts. The benefits of this aspect of the strategy were clear in an interview with a student who explained that drawing an image that represents gravity helped him understand this concept and better commit it to memory:

Interviewer:	So what is that a picture of?
S3:	The two objects pushing against one 'cause of gravity …
Interviewer:	Okay, so you think that helped you?
S3:	Yeah, because if a person is looking at it, they'll have an image put in their head, and they'll think of what you tried, and I put 'gravitational pull' here.
Interviewer:	When you think of gravitational pull, you think you'll see the two images?
S3:	Yeah, or pushed apart or something.

By directing students' attention to important information and systematising and organising the note-taking process, the SN intervention opened new opportunities for our study participants to think about their own cognition and to process and translate new knowledge. These findings impact how we understand the usefulness of cognitive scaffolding as well as the mechanisms by which such scaffolding can help students with LD address their biggest learning challenges.

Discussion

The SN intervention offered new possibilities for students' metacognition and their use of executive functions. It scaffolded key cognitive skills involving processing what information was important and how to translate and use that information. Interestingly, this scaffolding was multidirectional and highly structured, features that helped students suppress ineffective strategies and employ effective strategies.

Processing importance

The SN strategy offered students with LD explicit and implicit messages about what was important to know and include in their notes, in this way scaffolding cognition and prompting metacognition. As they used the CUES+ strategy, students relied on executive functions, which involved making decisions about the degree of importance of information they encountered, grasping concepts that had been communicated to them verbally, and translating and organising that information into a product that they could use to extend their learning beyond the class period in which the lecture took place (Miyake et al. 2000; Peverly 2006).

First, both our qualitative findings – that the CUES+ note-taking strategy strengthened students' WM and helped them to process new content knowledge – and quantitative results suggest that these students with LD were becoming better and more efficient note-takers. Students' ability to record more information increased after the implementation of the SN intervention. Interestingly, the greatest increase was in CLP. This increase implies that students improved the most in their ability to record important information that the teacher has presented as crucial to remember. Together, our qualitative and quantitative findings suggest that the SN strategy helped the study participants learn to distinguish important content from less important content. These students were engaged in a process of evaluating content as they heard it in order to predict what knowledge would be most useful to them after the lecture. In this way, students whose most pressing challenge is to wade through too much information at once (Mastropieri, Scruggs, and Graetz 2005) learned to create a product – a set of notes – that distilled a complex science lecture to only its most helpful content.

Students with LD often feel overwhelmed by decisions about the relevance of the information they encounter. In the case of taking lecture notes, this anxiety manifests as a tendency to either write down everything or write down very little. Either way, with the exception of CLP, the process by which they select what information to include or exclude is relatively arbitrary, more likely reflects their confusion at facing a barrage of (mostly unfamiliar) information than constituting conscious choices about how to understand and represent new ideas (Suritsky 1992). With these challenges in mind, honing what we call 'strategic inhibition' by learning to ignore irrelevant information provides this population of learners a much needed tactical bridge across what they are hearing in a lecture and what appears in their notes. Using the CUES+ intervention, students came

to suspend their all-or-nothing impulse in the note-taking process. Instead, they learned to actively use explicit messages (teacher cues) and implicit messages (pre-test clues) in order to engage in metacognition and utilise – and thus hone – executive functions. Importantly, in order to take advantage of the cognitive strategies that CUES+ scaffolded for the students, they had to actively stop using their previously unsuccessful strategies for making sense of and using new information.

Scaffolding as a multidirectional tool

Our findings also reveal the usefulness of scaffolding to promote metacognition in students with LD before, during and after lectures. The CUES+ pre- and post-test served to scaffold how and what students learned by directing their attention inward to the gaps in their existing knowledge and outward to the potential for the science lectures to fill in those gaps. Our analysis reveals that students engaged multi-directionally with the pre-test. Study participants not only responded to pre-test questions to reveal what they knew, they also used the questions to actively attend to their own thinking. For these students with LD, pre-test questions that were particularly challenging or on which they had hazarded arbitrary guesses served as markers of content that was important and that needed to be included in their class notes once they were listening to the lecture. Effectively, this scaffolding facilitated the central executive (attention) component of WM, the need to pull important information from everything one hears and distinguish it as such (Baddeley 2000).

During the lecture, in order to know whether or not a point was important enough to include in their notes, students used this scaffolding to listen, assign meaning to what they heard, recall their original understanding (or misunderstanding) of the subject and then make a split second judgement about whether or not what they were hearing matched with their pre-lecture knowledge and, therefore, whether or not it was a worthwhile point to write down. This use of controlled attention to inhibit irrelevant information and streamline relevant information to previously held schema is particularly important for students with LD, whose difficulties controlling attention make a demanding task such as note-taking feel daunting, to say the least (Hasher, Lustig, and Zacks 2007).

Organising complex information

As our interviews demonstrated, the CUES+ strategy also scaffolded students' metacognition by establishing a clear structure that required them to fill in the parts of the note-taking format. Indeed, this format helped the students engage in a kind of active listening that prompted metacognition. The CUES+ note-taking format can be understood as an artefact with which students interacted in order to actively listen to and process their science lectures, and interacting with this artefact increased their awareness of the cognitive processes, tasks and strategies that were most useful to them as they sought to understand and retain information from the lectures. By directing students with LD to actively attend to several inter-related tasks at once and make connections between old and new information in order to capture all the components of the CUES+ notes format, the CUES+ intervention exercised their executive attention and thus shaped how they used their WM.

The task of note-taking places cognitive demands on students, and successful note-takers respond to those demands with strategies for listening, comprehending and translating information (Piolat, Olive, and Kellogg 2005). Metacognition plays a key role in helping students know when and how to deploy these strategies (Flavell, Miller, and Miller 2002). Past studies have found that students with LD tend to struggle with such tasks because either they do not

have a strategy, they have a strategy but it is inefficient, or they have an adequate strategy but they do not know how to use it (Ellis and Lenz 1996; Gersten et al. 2001; Graham and Harris 2003; Pressley et al. 1989; Wong 1996). For the students in our study, using the CUES+ strategy when they entered note-taking situations gave them a viable strategy where they once struggled. More importantly, they had been taught explicitly how to use this strategy and were given many chances to practise it by interacting consistently with the same artefact – the SN format. As a result, the artefact reduced some of the cognitive demands of note-taking, ultimately affording them better use of their executive functions.

For students with LD, the complex task of note-taking is particularly difficult precisely because it divides their attention between listening and processing information and writing (Swanson and Saez 2003). CUES+ gives students a structure by which to interpret information as they hear it, offering them clear options for deciding what to do with that information – where to place it in the note-taking template and how to translate it into language that they can understand. These explanations can also take the form of pictures and symbols, which are more concrete and more efficient than words. In this process, the students are translating the lecture ideas into *knowledge constructs* as a means of building on topic-specific schema (e.g. ion engine is one type of plasma rocket), continually updating these schema, and communicating their new understandings in their notes (Nuthall 2000).

In summary, as students with LD used the SN intervention, they thought about note-taking differently and developed new strategies for making decisions during lectures (i.e. what was important to record in notes and what to ignore). After being taught the SN intervention, students now knew which aspects of the lecture required more focused attention. They also used the pre-test as a tool to prime themselves to process incoming information and used the CUES+ strategy as a way to organise large content into manageable chunks. For teachers, the lessons learned from this study can help them better understand some of the cognitive issues students with LD face while recording notes during lectures.

Conclusion

Our study has several important implications for teachers as they attempt to better prepare students with LD for cognitively demanding tasks, such as note-taking, in order to create a truly inclusive learning environment. Our findings demonstrate the usefulness of a particular kind of scaffolding in helping these students engage in metacognition. Teachers can give students advance organisers that offer them clues about what will be covered in the lecture and highlight the most important topics. This kind of scaffolding pre-emptively organises a lecture so as to give students a sense of the chronology of what is to come, effectively preparing them for the task of listening. Scaffolding also directs students' attention to key points. The practice, therefore, helps them to make split second decisions about information they encounter in the course of the lecture, ultimately developing their ability to employ successful strategies for using WM. For students with LD, approaches like this one help them sort through the overload of information that is presented in a lecture so that they can make decisions about what should be the most important 'take-aways' from the lesson. In effect, scaffolding lectures communicates to students that not every piece of information they encounter is going to be important, and it is a practice that offers the teacher the opportunity to ask, 'What do I want my students to remember about this subject a long time from now?' Besides helping students with LD learn important skills that can serve them in future academic pursuits, this practice also has the potential to make learning environments more equitable so that all students can be successful in interpreting and using the information presented in lectures.

Our analysis also extends current theorising on metacognition and WM by demonstrating how these two theoretical strands intersect and speak to each other. Literature on metacognition considers the way individuals use strategies for learning. This literature characterises learners as agentive, while literature on WM is focused on the subconscious processes that are occurring as learners take in information and use it. Neither theory adequately explains what occurs during the process of taking notes during a lecture. The concept of WM does not account for learners' purposeful employment of strategies for organising and understanding new information, and theories of metacognition are not able to explain the role of suspending information in one's memory in order to use it. Separately, then, neither theory can capture the way students experience note-taking.

Our analysis demonstrates that the scaffolding offered by the CUES+note-taking approach has the power to engage students as agents in their learning, forcing them to think about the way they process information from lectures so that they can purposely and consciously revise their internal, usually subconscious, use of WM. With CUES+, students consciously adopted a new strategy that helped them think about their own weaknesses and told them how to purposefully use components of WM. They used attention and inhibition in the context of an organisational tool that helped them translate information and alter their schema.

In conclusion, despite lecture note-taking being such a cognitively demanding activity, teachers can take steps to better prepare students for dealing with the multiple simultaneous learning tasks of active listening, making choices about the relative importance of information they are hearing, suspending that important information in their memory, interpreting its meaning and translating ideas into written form. Through the scaffolding and explicit strategy instruction provided in our study, students with LD were better able to tackle complex cognitive tasks. Most importantly, these strategies are accessible and useful to a wide range of learners for taking notes in a variety of content-area classes, ultimately increasing inclusivity by offering students with LD ways to tap into a wider range of learning opportunities.

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